ART. IV.—*Silliman's Chemistry.*

Elements of Chemistry in the order of the Lectures given in Yale College. By BENJAMIN SILLIMAN, Professor of Chemistry, Pharmacy, Mineralogy, and Geology. In two vols. New-Haven. 1831.

If the excellence of a work consist mainly in its adaptation to the professed object for which it was written, this truly is one of the best productions on the subject of Chemistry, that we have ever examined. In the preface, the author informs us, that 'the object of this work is to present the science in the most intelligible form to those who are learning its elements'; and the principles laid down, the facts adduced in support of these principles, and the mode of their presentation, are all in keeping with the design. Throughout the whole, he evidently proceeds on the ground that the students for whose use it was prepared, are entirely unacquainted with the subjects of which it treats; that he is writing for the novice and not for the initiated; and he endeavors, and we think very successfully, 'to find his way into the mind of the pupil, and to fix there the knowledge presented to him.'

When Sir Humphrey Davy composed his work on Chemical Philosophy, he had a different object in view; namely, to classify and arrange the great phenomena of the science in such a manner, that Chemistry, arrayed in all the glories of his brilliant discoveries, might not fear to take her proper rank with her sister sciences. Though he probably fell short of what was due from his fine genius, he produced a very valuable work for the master, but not such an one as the student wants. Dr. Henry's 'Elements of Experimental Chemistry' is in some degree chargeable with the same defect; for it is evident, that his eye is directed rather to the new discoveries in the science, than to what has long been known; and that in the composition of the work he was thinking more of chemists than of learners; so that while he is careful not to depart from the dignity of science, he has failed of communicating all that interest to his work, which it ought to have to recommend it to those who have but just entered on the study of Chemistry. He is correct and discriminating, and the successive editions present a fair view of the progress of the science. But however excellent the works just mentioned are, the one as show-ing great genius in generalizing, and the other a sound judgment, they are neither of them well adapted to be text-books in our colleges.

In the preface to the work before us, the author remarks, that

'The materials of this work have been gradually accumulating since 1802. They have been drawn from scientific journals, from the transactions of learned societies, and from the principal writers who have flourished since the middle of the last century, —*the Augustan age of Chemistry.* From works of an earlier date, light has been occasionally derived, as well as from notes and recollections of the instructions of the distinguished teachers, to whom the author was formerly so happy as to listen. In this view, he takes particular satisfaction in naming the late Dr. Murray of Edinburgh, and Professor Thomas C. Hope, still a distinguished ornament of the university in the same city.

'Various notices, derived from the author's own experience, and from his personal communications with others, are introduced, with occasional figures, for illustration; and in the notes, many miscellaneous facts are preserved.

'In the immediate preparation of this work for the press, the original memoirs of authors and discoverers have been often consulted, and the abstract has been frequently drawn from them, rather than from the elementary books; but the analyses contained in the latter have not unfrequently been adopted; sometimes even after a careful examination of the original; and for this reason, among others, that the statements contained in them could be often, without injury, still further abridged. In such cases, several eminent elementary writers have been diligently compared on the same subject; and thus omissions have been supplied, and obscurity has been removed, either by the comparison or by resorting to the first record.

'References to the original memoirs have been always preserved, when such memoirs were attainable; and when the books containing them were not at hand, the citations have been copied from the latest systematical writers. Credit has also, in most instances, been given to elementary writers for materials drawn from their pages; but for brevity, and especially when the facts are the common stock of the science, the references have been sometimes omitted, or an initial letter only retained. There are, however, some works, to which a more particular acknowledgement is due. Those of Bergman and Scheele; the lectures of Dr. Black, by Robison; the system of Dr. Thomson, in all its editions, and also his more recent work on the First Principles of Chemistry; the Dictionaries of Nicholson, Aikins, and Ure, the Compendium of Dr. Hare, the Dispensatory of Dr. Coxe, the Technology of Dr. Bigelow, the Operative Chemist of Gray, and the Chemical Manipulation of Mr. Faraday; the System of the late Dr. Murray, and his Elements, ably edited by his son; as also the writings of Mr. Dalton; the works of Lavoisier, Chaptal, Berthollet, and Fourcroy; the System of Thénard, in its most recent edition, and his miscellaneous writings, especially in connexion with Gay-Lussac; and those of Dr. Priestley, Bishop Watson, Mr. Parkes, Professor Berzelius, and Sir H. Davy, including also his Elements;—these are among the leading authorities, although it would be easy to increase the catalogue.

'A recent work by Dr. Turner, of the London University, has been of great utility. It is highly scientific and very exact, particularly on the facts and doctrines of definite and multiple proportions, and combining equivalents; and many of its details have been adopted.' Preface, pp. 4, 5.

After the preface comes the plan of the work, which we shall again have occasion to notice, and then follows an introduction, containing a spirited sketch of the main branches of natural science, and the connexion between them.

'CHEMISTRY. The remaining branch of science relating to natural bodies, begins where natural philosophy and natural history stop. As the gleanings of its early history may be found in the prefaces of the larger elementary works on Chemistry, we shall here omit the vague annals of its infancy, and the delusions of its middle age.

'It would exceed our limits to trace the progress of Chemistry from age to age; to unfold the delusions of ALCHEMY, whose object was to discover the philosopher's stone, an imaginary substance, which, it was supposed, would convert the baser metals into gold or silver, or to speak of the equally delusive pursuit after the GRAND CATHOLICON, or universal remedy, which was to remove every disease; to avert death, and confer terrestrial immortality on man; or to mention the imaginary ALCAHEST, or universal solvent, whose power it was supposed nothing could resist. The alchemists indeed imagined, that these miraculous virtues resided in one and the same substance, and during the dark ages, most of the cultivators of what was then called Chemistry, smitten with the delirium of Alchemy, pursued their occult processes in cells and caverns, remote from the light of heaven, and wasted their days and nights, their talents and fortunes, in a vain pursuit. The alchemist, however, accumulated many valuable facts, which have been employed with good advantage, in laying the foundations of modern Chemical Science.

'Some knowledge of chemical arts is coeval with the earliest stages of human society; and it has happened with this, as with other branches of natural knowledge, that many facts were discovered and accumulated, in the practice of the arts, and in domestic economy, long before any general truths were established, by a course of inductive reasoning, upon the phenomena.

'The arts are all either mechanical or chemical, and not unfrequently both are involved in the same processes. The practices of the arts may be regarded as experiments in natural philosophy and chemistry. The object of the arts is usually gain; but he, or any other person, who views the facts correctly, may reason upon them advantageously, and thus obtain important instruction.

'The *Science* of Chemistry, considered as a collection of elementary truths derived from the study of facts, can scarcely be referred to a period much beyond the commencement of the last century, and its principal triumphs have been achieved since the middle of that period. It would be premature, to detail on the present occasion, the particular discoveries, which, like stars, rising successively above the horizon, have broken forth in rapid succession. Those discoveries, their periods and their authors, will be mentioned, in giving the history of each particular substance. At present, it would not be proper to attempt any thing more than to convey to those to whom the subject may be new, a general conception of the nature, extent and objects of the Science of Chemistry, reserving the details for the time when they will be both the most intelligible and the most interesting.

'DEFINITION.* *Chemistry is that science which investigates the composition of all bodies, and the laws by which it is governed.*

'Not satisfied with the knowledge of the external properties and the mechanical relations, which are unfolded by natural history and by physics, but taking them into view, and retaining and using their principal discoveries, chemistry proceeds to investigate the hidden constitution of every species of material existence in earth, sea, and air.

'*Earth, air, fire, and water,* were the four elements of the ancient school. They have, however, yielded to analysis, and water, bland and simple as it seems, contains two bodies, whose properties are entirely different from its own and from those of each other; burning, when mingled and ignited in large quantities, with violent explosion; and in a small stream, with a heat, which melts and dissipates the firmest substances. We should never have conjectured that water, whose great prerogative it is

* 'For various definitions the student may see the principal authors, Thompson, Fourcroy, Henry, Murray, La Grange, Thénard, Davy, Brande, Turner, Hare, and others.'

to extinguish fire, contains both a combustible and a supporter of combustion.

'*The air*, the *pabulum* of life to the whole animal and vegetable creation, mild and negative like water, is not *simple*, but incidentally contains many bodies,—essentially, however, only two; one of which, and that constituting four-fifths of the whole, is, and was intended to be, in a high degree noxious and even deadly to animal life, and fatal to combustion. The air does not destroy life instead of invigorating our frames, and extinguish instead of inflaming combustion, because the prevalent noxious principle of the air (nitrogen) is balanced by a life and fire-sustaining principle, (oxygen) too vigorous to be trusted alone, and therefore diluted exactly to the proper degree by the opposite principle; both being, by another extraordinary provision, sustained, in constant proportion, and thus producing a salubrious and unchanging atmosphere.

'The *earth* under our feet, the soil, the sand, the gravel, the firm substance of the rocks, is not simple. In this ancient but assumed element, we have a double complexness. The one imagined simple earth contains at least nine, and each of these is again complex, containing for one principle, oxygen, the same that exists both in water and in the atmosphere, united to nine or ten varieties of metals or combustibles, none of which are known in common life.

'He who is acquainted with the wonderful effects of chemical combination, will not think it strange that half the weight of marble is carbonic acid, and that metals, when combined with oxygen, resemble very exactly the earthly substances.

'*Light as well as heat*, is contained in common fire, and therefore it is not simple, unless fire and heat are varieties of one and the same thing.

'Modern research has proved that, besides light, which, in its seven prismatic colors, is contained in the solar beam, there is also, in this emanation, an opake, radiant principle, which accompanying light and heat, neither warms nor illuminates, but acts to decompose certain chemical compounds; that there are opake rays which warm but do not illuminate, and illuminating rays which are cold to the sense of living animals, but impart to the universe its splendid drapery of colors; and that, associated with one or more of these emanations, there is a surprising power, which imparts magnetism to a needle, and gives it the properties of the load-stone. But we have used the word element without defining it.

'*An element is an undecomposable body*,—it is therefore simple, or in other words, not reducible to any other form of existence.

We must, however, carefully distinguish between *real elements*, and those which are such only in relation to the present state of our knowledge. When modern science speaks of a body as elementary, it intends nothing more than that it has not been decomposed. It is therefore simple as far as we know, but it is possible that by future efforts, it may be decomposed. Although we have no reason to doubt that there are *real* elements, we cannot say that we are certainly in possession of any one element. It is, however, perfectly safe to reason upon bodies as elementary, until they are proved to be compound. Iron is, as far as we know, a simple body; we cannot as yet exhibit it in any simple form; all we can do, is to alter its size and figure, without at all changing its nature. But iron rust, or the scales which fly off when red hot iron is hammered, are not simple; they consist of iron combined with oxygen, one of the principles of the atmosphere; we can explain these substances in a simpler form; the iron which they contain can be separated from the aerial principle, and both can be exhibited apart, and thus the proof will be complete; red lead and red precipitate are still better examples, because the former can be partially, and the latter wholly, brought back to the condition of metals, by simply heating them.

'The four ancient elements, earth, air, fire, and water, were assumed at hazard, because they are so conspicuous and important; the conception was grand, but it was wholly erroneous.

'Instead of four elements, we have at the present time not less than fifty, nearly four fifths of which are metals; the remainder are chiefly combustibles and bodies which, combining with combustibles and metals with peculiar energy, are generally called supporters of combustion.*

'Our simple bodies then are,

1. Metals, about . . . . 40†
2. Combustibles not metallic, ... 7†
3. Principles or supporters of combustion, . 2 or 3
4. One body, or possibly two,‡ of an undetermined character, in all . . . . . 50 or 51
5. Imponderable bodies, light, heat, and electricity; besides the power called magnetism and the other varieties of attraction.

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* 'Some object to this phrase, preferring to consider combustion as being only an example of intense chemical action; this view is philosophical; but combustion is so frequent an occurrence, and involves so many important chemical events, that it is convenient, in accordance with the general practice of mankind, to designate it and the bodies contained in it, by a peculiar phraseology.'

† 'It is perhaps doubtful, where some of these bodies ought to be classed,—whether among metals or combustibles.'

‡ 'Perhaps silicon and bromine; we have, however, classed them where they appear to belong.'

'The principal object of Chemistry is to display, first, the great powers upon which its phenomena depend; and, secondly, the properties of the elements, the mode and energy of their action, the combinations which they are capable of forming, the properties of the resulting compounds, and the laws by which they are governed. This statement obviously includes all bodies, natural and artificial. There are many chemical compounds made by art, which, as far as we are informed, do not exist in nature, and there are many natural bodies which art has not yet been able to imitate.' Vol. I. Introduction, pp. 14—19.

We have already expressed the opinion, that this work is eminently adapted to the object for which it was prepared, and one circumstance which shows that it is so, is the vast number of interesting facts contained in it, illustrating most distinctly and satisfactorily the principles of Chemistry. They are drawn, not merely from the experiments of the laboratory, but likewise from the shop of the artist, and the grand processes of nature. They are not only such as are found scattered through elementary works and scientific journals, but they are also such as the author himself gathered from his own experience and observation, during the nearly thirty years which he has devoted to the subject. They are also, many of them at least, related in a manner so distinct, graphic, and attractive, as to prove that he is not only a close observer, but a warm admirer of this class of the phenomena of nature.

Now this is just what the student wants, as one said a few days since, who was endeavoring to glean some knowledge from a dry text-book. 'I should be very much interested in Chemistry, if I could find *data*.' It is peculiarly a science dependent upon facts, which are needed to give a local habitation to its doctrines; and without them, though one should write a system with all the acuteness of Aristotle, and the elegance of Plato, it would not interest a novice any more, than would a metaphysical system of divinity, compared with the narrations of the Evangelists. Every science has its metaphysics, and we know there are some who would prefer a cold statement of the abstract principles of Chemistry; just as there are those, who, from their attachment to Anatomy, would feel more interest in a naked skeleton than they would in a form through which life pours its mantling tide, and in which intelligence dwells. And we apprehend that in the progress of investigation and discovery, the tendency is to lay aside facts and to dwell on principles. One chemical philosopher, in all the ardor of original investigation, arrives at certain conclusions, which he publishes to the world with the facts upon which they are built, and the uses to which they can be applied. Another, adopting these conclusions as his premises, while he says little about those facts or those uses, presses on in the field of discovery, and in his turn enlarges the boundaries of knowledge. And it has happened, that some of the late works on this source are very deficient in those interesting phenomena, upon which its great principles are founded, and in the discussion of the practical application of those principles; while they are fuller than the older systems of the doctrines of the science. This is the case with Dr. Turner's recent work; which is worthy of all praise for the philosophical accuracy of its statements, and yet has very little attraction for one who has just entered on the study of the science, as we have had good opportunity of knowing. And here we are happy to fortify our opinions, by quoting the kindred sentiments of Dr. Ure, from the preface of his Dictionary of Chemistry.

'It must however be confessed, that the listlessness with which chemical systems are frequently perused, is not entirely the fault of the reader. Too many of these books are dry compilations of names, qualities and numbers, in methodical complexity, containing no intelligible examples of chemical inquiry; nay, hardly a trace of the genius of discovery or of the splendid course which it has run.'

The same good judgment which appears in the selection of a great number of facts, led the author to dwell on those doctrines, that are the most important and interesting; and this is another circumstance, which renders the work well adapted to the purpose for which it was prepared. When Nicholas Lemery published his course of Chemistry, we are told that it was devoured like a novel, and we are disposed to believe, that by a selection of certain topics, illustrated in a suitable manner, a book might be prepared which would be equally attractive at the present time. Let the grand doctrine of *caloric* be exhibited, with its various phenomena of radiation and slow communication; in its vanishing and re-appearing forms, according as it becomes latent or sensible, with its several sources and its powerful effects, whether they are seen in clothing the earth with verdure and working into life the tribes that people it; in changing the dimensions and the state of bodies by its expanding and decomposing power; or as they appear in the steam-engine, the noblest trophy of the conquest of science over nature; and in the volcano, which sends forth from the interior of the earth its desolating flood. Let the simple combustibles, such as carbon, phosphorus, sulphur, and hydrogen find a place; and the grand supporter of combustion, oxygen, in its several states, solid in union with the metals, liquid in the water we drink, gaseous in the air we breathe; united with one class of bodies to form the alkalies, earths and oxyds, and with another to form the common acids; expanded in large quantities to support animal life, and, by a beautiful arrangement of Providence, restored to the atmosphere by the vegetable creation. To these should be added chlorine, some of the more important metals, some of the proximate vegetable principles. It would be highly important not to omit galvanism, with its wonderful phenomena, and the laws of affinity, especially as they are exhibited in the doctrines of definite proportion. Let these and some other topics be selected and presented with sufficient detail in an appropriate form, and in the same spirit with which Sir Humphrey Davy wrote his last work, though in a less ambitious style, and the science could not fail of awakening a deep interest, and of securing more attention than it now does.

Chemistry has become very extensive in its ordinary branches and applications, and we see not why the same course should not be taken in preparing works for the learner, on this as on most of the other sciences. He who prepares a work for schools and colleges, on arithmetic, or algebra, or geometry, does not think it necessary to include in it the theory of numbers, or of analytical functions, or the porisms recorded by Pappus; and for the plain reason, that these investigations would not only be of no use to the student in his incipient course, but from their intricacy, would be actually discouraging and repulsive. But in the larger works on Chemistry, such as for instance, Thompson's, Murray's and Henry's, there are subjects introduced, with which it is impossible that a student should become acquainted in the time usually allotted to the study of Chemistry in our colleges, and which must serve only as stumbling-blocks in his way.

We are happy to find that M. Lavoisier justifies this view of the subject, in the course which he took in the composition of his work; though the reasons for it, owing to the progress of the science, are much stronger now than they were when he wrote. Having omitted the subject of affinities, he remarks in his preface that he had done so, because he considered the 'science of affinities as holding the same place with regard to the other branches of Chemistry, that the higher or transcendental Geometry does with respect to the simple and elementary part.'

In the work before us, Professor Silliman, while he has conformed to the common mode of saying something on every substance, has, for the most part, bestowed attention upon each according to its relative importance, presenting some of them in a strong light, and casting into the shade others of less importance.

The next circumstance to be mentioned, which renders this work well adapted to the object for which it was prepared, is its arrangement. Had it been prepared for the purpose of presenting to thorough-bred chemists a logical view of the various substances in nature in their relations to each other, perhaps the order in which the subjects are treated, would not have been in every respect the most scientific ; while it may be the best that could be devised for those for whose use it was especially designed, and who are supposed to know absolutely nothing on the subject of Chemistry. The problem to be solved was, what is the arrangement best adapted to awaken and sustain an interest in their minds, and communicate to them clear and adequate views of the science ? and from his long experience and great success as a teacher, we think that no one is better qualified than the author to furnish a solution. There is an inherent difficulty in the case, which does not exist in the exact sciences, and it is not surprising that a man trained in these, should be dissatisfied with any system that can be proposed.

Bodies are frequently related to each other in themselves, or in their proximate principles, or in their ultimate principles.

For instance, carbonate of potash and carbonate of soda agree with each other in being made up in part of carbonic acid ; and after this is removed by lime, the two substances, potash and soda, agree in being made up in part of oxygen ; and after this is removed by iron turnings or charcoal, the two substances agree in being metallic. Now let a classification be adopted, founded on either of these relations, and there will be practical inconveniences of one kind or another, if the system be carried through. For particular bodies it would not be very difficult to determine what should be the arrangement, yet a mode that would answer for these, would not answer for all others. Among the British chemists, there is considerable diversity in their systems of arrangement, and which of them has adopted the best, it would be rather difficult to say; we are sure it is not Dr. Thompson, however meritorious he may be in other respects.

We are inclined to believe that too much importance has been attached to a logical system, just as theologians formerly thought lightly of doctrines, which could not find a place in some body of divinity. Instead of entering at large into arguments in support of our opinion, we shall barely allow ourselves space to quote a paragraph from Dugald Stewart's Dissertation on the Progress of Philosophy. Page 248, 1 dis. part II.

'The passion of the Germans for *systems*, is a striking feature in their literary taste, and is sufficient of itself to show that they have not yet passed their noviciate in philosophy.' "To all such," says Mr. Mc Laurin, "as have just notions of the Great Author of the Universe and of his admirable workmanship, all complete and finished systems must appear suspicious."

'At the time when he wrote, such systems had not wholly lost their partisans in England, and the name of *system* continued to be the favorite title for a book, even among writers of the very first reputation. Hence the *System of Moral Philosophy*, by Hutcheson, and the *Complete System of Optics*, by Smith, titles which, when compared with the subsequent progress of these sciences, reflect some degree of ridicule upon their authors.'

In the plan of the work before us the author remarks,

'I have not thought it best to describe the simple substances in uninterrupted succession. Such a method does not appear to me to present advantages sufficient to compensate for the inconvenience of plunging at once into the most complex parts of the science; which must be done, if we would draw the elementary bodies from their combinations, and present them in the beginning in a connected view.' p. 1.

'The natural process of acquiring knowledge is the analytical, or the progress from the complex to the simple, from the whole to its parts; the shortest is the synthetic, that is, from the simple to the complex; from the parts to the whole; and this is the course now more generally pursued in Chemistry. If our knowledge were perfect, this would be not only the most obvious, but the best process; and perhaps that mode will be found to combine most advantages, which unites them both. With this view, I have therefore sometimes adopted the one and sometimes the other, aiming to present the most important elements and combinations as early as possible.' p. 2.

'In teaching, the great object should be, *to find our way into the mind of the pupil, and to fix there the knowledge that we present to him.* He is ordinarily no judge of our theoretical views, with regard to classification and arrangement; he will in most cases even fail to understand us, when we discuss them; and he will be best satisfied with that course, which, in the most interesting and intelligible manner, presents to him the greatest amount of useful knowledge. Both in my public courses of lectures, and in the present work, I have, therefore, considered this object as paramount in importance to every other.' p. 3.

Another circumstance which adds very much to the value of the work, is this, that it presents the doctrines of Chemistry in their connexion with the practical arts of life. There is enough, indeed, in the grand and beautiful phenomena they unfold, to awaken interest and secure a generous and lasting attachment to the science from its own intrinsic excellence and beauty. But it must be confessed, that the *amor habendi* has gained a place in so many hearts, that even science herself is loved mainly for the dower she brings. You must convince men that Chemistry will enable them to increase their wealth, before they will consider the study of it as worthy of their attention. It was said by one, who had borne the honors of his country, and by his counsels had helped to increase her resources, in speaking of a young lady who was about to commence the study of Chemistry, 'Why, if it will help her to make a better pudding, let her study it.' Now to men of this class, who value every thing as it contributes to the amount of national or individual wealth, Chemistry, in its application to the arts, presents strong claims, as the experience of France can testify. Formerly, the arts were enveloped in mystery and concealment. They stood separate from each other, and a knowledge of some one of them was frequently transmitted from father to son as a valuable inheritance. But the lights of modern Chemistry have disclosed these confidently treasured secrets; and besides introducing a great many new arts, have shown a connexion between those already known, that was not suspected to exist before.

It is in this way that Chemistry, by discovering the laws of nature, has been a source of wealth to those who have applied these laws to the practical arts of life, and enabled them to realize for themselves and their country, that of which the votaries of alchemy only dreamed.

Professor Silliman has generally mentioned the uses to which the various substances described are applied, and not unfrequently, some of the processes by which this application is made. As, for instance, under *silicia*, he mentions some particulars concerning the manufacture of glass; under *alumina*, the process for making porcelain and pottery; and under *nitre*, the mode in which gunpowder is made.

This work was needed. It was due from the author that he should promote the science by his pen, as he had long done by his lectures. It was due to the Institution with which he has been connected, with so much reputation to both. The science has undergone almost as many changes as the objects in the vegetable, the animal, and mineral kingdoms, which it investigates, though no valuable truth is lost. *Omnia mutantur, nil interit.* Take as an instance the theories of combustion. At one time, the doctrine of phlogiston prevailed, with its successive modifications. In place of this, the views of Lavoisier were brought forward, and his house, we are told, became a temple of science, where the Parisian chemists held a festival, at which Madame Lavoisier, in the habit of a priestess, burnt Stahl's *Fundamenta* on an altar, while solemn music played a requiem to the departed system. Then followed the doctrines of Davy. A science thus constantly changing requires a work suited to its present condition, enriched as it has been within a few years by a succession of brilliant and useful discoveries, and such a work is the one before us.

Art. V.—*Croker's Boswell.*

The Life of Samuel Johnson, L.L. D. Including a Journal of a Tour to the Hebrides. By James Boswell, Esq. *A New Edition. With numerous Additions and Notes.* By John Wilson Croker, L.L. D. F. R. S. *In five volumes octavo.* London. 1831.

We do not know the literary work, which has acquired a greater or more universal popularity than Boswell's Life of